Risk Factors of Postprocedural Hypotension Following Carotid Artery Stenting

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Key words: stent, postprocedural hypotension, prolonged, carotid artery

Summary

This study is performed to investigate risk factors of hypotension in response to elective carotid stenting. Forty-four lesions of 40 consecutive patients (mean age 70.4 ± 8.2 years) were retrospectively analyzed. Easy Wall stent was applied in 15 lesions and SMART stent in 29 lesions. We investigated correlations between the occurrence rate of postoperative hypotension below 90 mmHg and persisting over three hours and findings of preoperative angiograms, ultrasonograms and clinical characteristics. Postprocedural hypotension occurred in 19 patients (47.5%) and medical treatment (intravenous administration of catecholamines) was required in eleven patients (27.5%). Although there was no permanent neurological deficits related with postprocedural hypotension, transient neurological deficits were found in three patients. Risk factors of prolonged postprocedural hypotension were statistically analyzed. On angiographic characteristics; 1) distance between the carotid bifurcation and the lesion with maximum stenosis (≦10 mm vs. >10 mm: $p = 0.031$), 2) type of stenosis (eccentric vs. concentric: $p = 0.014$) On ultrasonographic characteristics; 1) calcifications at the carotid bifurcation (present vs. absent: $p < 0.001$). Other variables, including age and degree of stenosis, were not associated with postprocedural hypotension after carotid stenting. These angiographic and ultrasonographic variables can be used to identify patients at risk for postprocedural hypotension after carotid stenting. Such identification may help in selection of patients who will benefit from appropriate pharmacological treatment.

Introduction

Carotid angioplasty and stent deployment (CAS) has been introduced as an alternative to carotid endarterectomy (CEA) for the treatment of carotid stenosis, because it is less invasive than CEA and the recent development of protective devices prevent us from distal embolism during CAS. Despite favorable results in initial series[1,2,3], the haemodynamic changes may complicate carotid stent procedure. Moreover, CAS tends to suite for patients at high risk for CEA, such as those with an occlusion of the contralateral internal carotid artery.

Although CAS involves extensive manipulation in the vicinity of both the adventitial baroreceptors and the carotid sinus, the frequency and predisposing factors of haemodynamic instability in the postprocedural period have not been investigated. To clarify the clinical significance of hypotension in the acute postprocedural period after CAS, we evaluated the effects of angiographic and echosonographic factors and clinical characteristics on development of hypotension.

Material and Methods

Thirty-four males and six females aged 38 to 79 (mean ± SD = 70.4 ± 8.2 years) with 44 lesions underwent CAS between October 2000 and July 2004. All preoperative stenotic ratio of the lesions were more than 60% (mean = 78.8%). There were eleven cases with bilateral lesions, including five cases with occlusion of the contralateral internal carotid artery (ICA). Six of the eleven patients had remarkable carotid stenoses on both sides, four were treated with CAS on both sides, but one was treated with CEA after CAS because of difficulty with catheterization. At least one month passed between procedures in the patients who were treated bilaterally. The remaining patient was observed after the initial CAS. Symptomatic or angiographically high-grade stenotic lesions were initially treated with CAS for these patients with bilateral stenotic lesions. Easy Wall stent (Boston Scientific Japan Inc.) was used in the initial 15 consecutive lesions and SMART stent (Johnson & Johnson Inc.) in the latter 29 lesions. For this study, hypotension was defined as a fall in systolic blood pressure (SBP) of >30mmHg and any episodes of SBP <90 mmHg. If the fall in SBP was sustained for more than three hours, it was considered prolonged postprocedural hypotension.

Procedure of CAS and Management of Hypotension during and after CAS

Control angiograms were obtained and the lumen diameters of the stenotic lesions and adjacent arterial segments were measured. Naviballoon (Kaneka Inc.) or PercuSurge (Medtronic Inc.) was used to protect against distal embolism in all cases. Intravenous atropine was given prophylactically prior to initial inflation of the balloon. After balloon inflation, the stent was deployed and the blood including debris was aspirated and distal protection was then released. If dilatation was inadequate (residual diameter stenosis ≥25%), postdilatation was added with distal protection. A final angiogram was obtained to confirm that no dissection or distal embolism had occurred. If hypotension was sustained despite of fluid loading and intravenous administration of atropine sulfate and vasoconstrictors, continuous intravenous infusion of dopamine was initiated to maintain SBP above 100mmHg (figure 1).

Evaluation of Angiograms, Ultrasonograms and Clinical Characteristics

We examined several factors related to angiographic and ultrasonographic findings to determine the risk factors for prolonged hypotension after CAS. On angiograms, we analyzed the following two factors; 1) distance from the carotid bifurcation to the lesion with maximum stenotis (<10mm vs. ≥ 10 mm), and 2) type of stenosis (eccentric vs. concentric) (figure 2). On ultrasonograms, we analyzed the following two factors: 1) echogenicity of the plaque (echogenic vs. intermediate~echolucent), 2) calcification at the carotid bifurcation (present vs. absent). Furthermore, we investigated how the occurrence of prolonged hypotension was affected by factors such as type of stent used

Table 1 **Evaluated factors for prediction of prolonged hypotension after CAS.**

Angiographic findings	Distance from CB to the lesion with maximum stenosis	(≦ 10 mm / <10 mm)
	Type of stenosis	(eccentric / concentric)
Ultrasonographic findings	Echogenicity of plaque	(echogenic / echolucent~intermediate)
	Calcification of CB	(present / absent)
Clinical characteristics	Age	
	Gender	(male / female)
	Lesion	(unilateral / bilateral)
	Type of deployed stent	(EasyWall stent / SMART stent)
	CB = the carotid bifurcation	

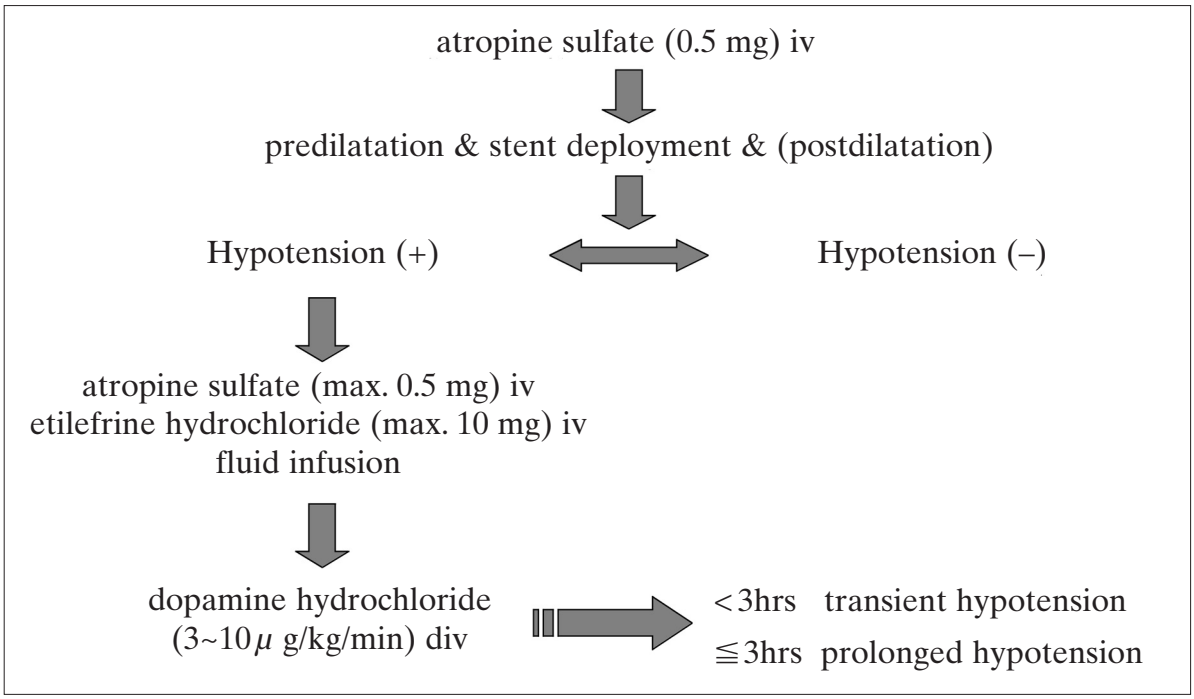

Figure 1 Medical treatment for vagal reflex in the carotid stenting is shown. Intravenous atropine sulfate (0.5 mg) was given in all patients for prophylaxis before the initial inflation of the balloon. If the hypotension is not disappeared in spite of temporary administration of intravenous atropine sulfate or etilefrine hydrochloride, continuous intravenous infusion of dopamine hydrochloride was initiated.

(Easy Wall stent vs. SMART stent) and other clinical characteristics such as age, gender, and lesion (unilateral vs. bilateral) (table 1).

We statistically analyzed these factors and determined the significant risk factors correlated with a development of prolonged hypotension after CAS. Univariate testing used chi-square and Fisher's exact tests as well as Student's t-test for comparison of proportions. Measures of association between risk factors and prolonged hypotension were also expressed as odds ratios with 95% confidence intervals. The level of statistical significance was considered to be $p<0.05$. Associations between risk factors and prolonged hypotension were also evaluated by multivariate analysis using logistic regression models.

Results

All patients achieved successful dilatation of carotid lesions by means of angioplasty and stent deployment (mean stenotic ratio = 78.8% to 15.4% measured by NASCET methods). Post-CAS hypotension developed in 19 (47.5%) patients and prolonged hypotension requiring intravenous administration of dopamine over three hours occurred in eleven (27.5%) patients. These periods of blood pressure instability lasted 16~72hours (mean 43.4 hours). Ischemic complications related to the hypotension after CAS were observed in three patients, but each was transient and had resolved completely.

Risk Factors for Prolonged Hypotension after CAS

Univariate analysis revealed that prolonged postprocedural hypotension was significantly more frequent in patients who had two angiographic characteristics. First, the distance from the carotid bifurcation to the lesion with maximum stenosis is under 10 mm ($p=0.031$). Second, the plaque of the lesion is eccentrically located ($p=0.014$). Furthermore calcification at the carotid bifurcation on ultrasonograms ($p<0.001$) was also associated with prolonged hypotension after carotid stenting. However, increased echogenicity of plaque ($p=0.558$) on ultrasonograms and other factors such as age, gender, and stenotic ratio were not significant

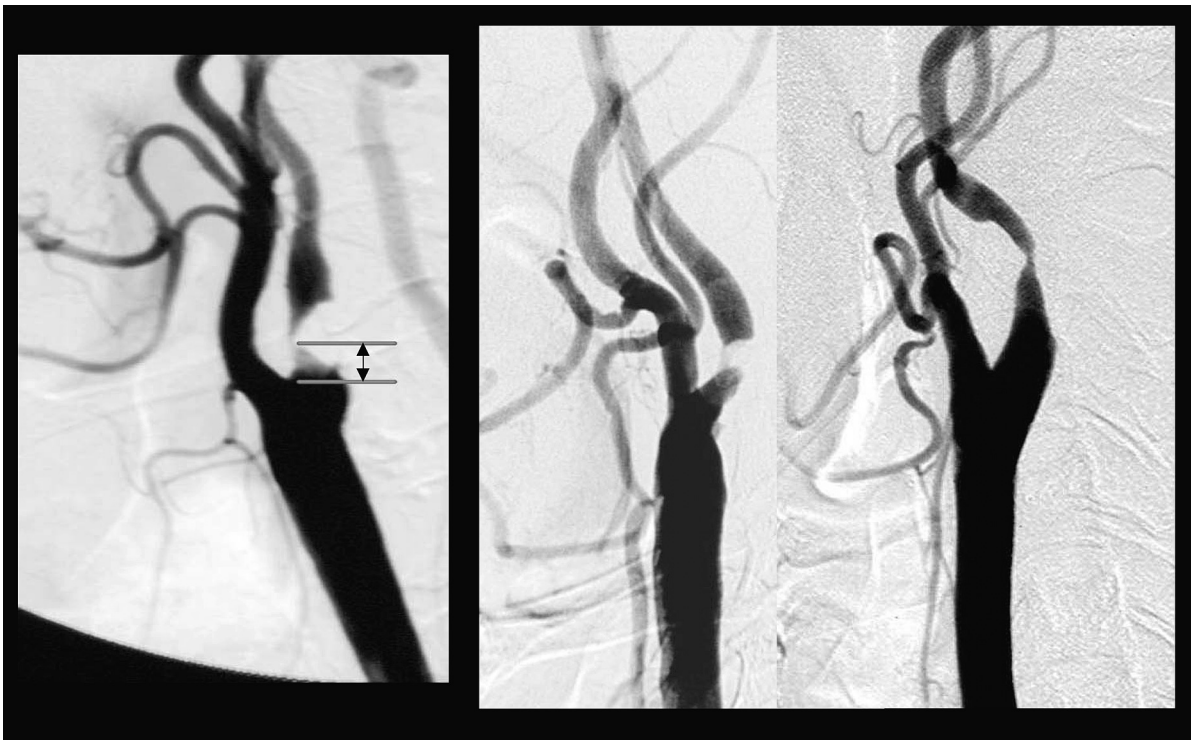

Figure 2 A) The method for measurement of the distance from the carotid bifurcation to the point of maximum stenosis in the lesion is demonstrated. B,C) Two types of the stenotic lesion are represented as eccentric type (B) and concentric type (C).

risk factors for prolonged postprocedural hypotension (table 2).These factors were also independent preoperative risk factors for prolonged postprocedural hypotension after CAS on multivariate analysis, although type of deployed stents was not a significant predictor of postprocedural hypotension on this analysis (table 3).

Discussion

Although CEA has been a standard method of treatment for carotid artery stenosis, haemodynamic instability after CEA has been linked to surgical morbidity and mortality [4,5,6,7]. CEA –induced hypotension has been demonstrated to correlate with poor outcome, as extensively described in the literature [8,9,10]. In the series of Ranson et Al.[11], hypotension after CEA was related to myocardial infarct in eight of nine patients and grave neurological complications in 14 of 29 patients. Haemodynamic instability has been considered an important risk factor for neurological complications after CEA [10,12,13].

Recently, CAS has been introduced as an alternative to CEA for the treatment of carotid artery stenosis [6,14], and is particularly suited for patients with high risk on CEA [15]. However, the phenomenon of haemodynamic instability has also been recognized after CAS and it might be clinically problematic.

Haemodynamic alterations that occur during and after CAS are probably mediated through dysfunction of adventitial baroreceptors (stretch receptors) located in the carotid sinus, which is dilated and stretched by intravascular stents. Impulses arising in the carotid sinus are transferred via the sinus and glossopharyngeal nerves to the nucleus tractus solitarius (NTS) in the caudal medulla. Stimulation of the NTS inhibits sympathetic nerve impulses to the peripheral blood vessels, leading to reduction of systemic blood pressure. Impulses from the carotid sinus also stimulate the nucleus ambiguous and dorsal vagal nucleus, thus increasing vagal activity and decreasing heart rate. These baroreceptors locate in not only the carotid sinus but also aortic arch stretch receptors, but the carotid sinus baroreceptors are more sensitive and produce greater changes in pressure than those in aortic

Table 2 **Risk factors for postprocedural prolonged hypotension by univariate analysis.**

Factors	Prolonged(+) 11	Prolonged(-) 33	p-value
Age (years old)	71.3±6.4	70.2±8.6	0,695
Gender (Female/ Male)	(1/10)	(7/26)	0,656
Lesion (Bilateral / Unilateral)	(2/9)	(10/23)	0,434
Stenotic ratio (%)	74.0±14.3	79.2±13.8	0,504
Stent (**SMART**/ EasyWall)	(10/1)	(19/14)	**0.035***
Distance from CB to the lesion with maximum stenosis (≦**10 mm** / >10 mm)	(10/1)	(17/16)	**0.031***
Type of stenosis (**eccentric** / concentric)	(9/2)	(12/21)	**0.014***
Echogenicity (echogenic / echolucent~intermediate)	(11/0)	(29/4)	0,558
Calcification of CB (**present**/ absent)	(8/3)	(6/27)	**<0.001***

*CB= the carotid bifurcation * statistical significance: p<0.05*

arch. Blood pressure is strongly modulated by reciprocal changes in vagal and sympathetic neural activity stimulated from carotid artery baroreceptors [16].

In our series, postprocedural hypotension occurred in 19 (47.5%) of 40 patients and eleven (27.5%) of 40 pateints required dopamine to maintain SBP above 100 mmHg. The frequency of hypotension after endovascular intervention has been found to be 13 to 56.1% [17,18,19], and persistent hypotension has been noted at a frequency of 48% to 72.7% of cases with hypotension [17,20].There is wide variation in these frequencies, because the endovascular intervention included some procedures such as angioplasty alone and stenting using balloon- expandable or self-expandable stents. Dangas et Al.[17] reported that post-CAS hypotension de-

Table 3 **Determinants of postprocedural prolonged hypotension derived from Logistic-Regression analysis.**

Factors	Odds Ratio	(95% CI)	p-value
Age (years old)			n.s.
Gender (Female/ Male)			n.s.
Lesion (Bilateral / Unilateral)			n.s.
Stenotic ratio (%)			n.s.
Stent (SMART/ EasyWall)			n.s.
Distance from CB to the lesion with maximum stenosis (≦**10mm** / >10mm)	9.4	1.1-82	**0.043***
Type of stenosis (**eccentric** / concentric)	7.9	1.5-42.6)	**0.025***
Echogenicity (echogenic / echolucent~intermediate)			n.s.
Calcification of CB (**present**/ absent)	12	2.4-59.1	**0.001***

*CB = the carotid bifurcation - n.s. = not significant - * statistical significance: p<0.05*

veloped in 26% of patients after balloon-expandable stent deployment vs. 9% after self-expandable stent deployment. Although we used two types of self-expandable stents, no significant difference was observed in the incidence of prolonged hypotension between them.

Prediction of persistent hypotension after CAS is quite important in preventing periprocedural ischemic events, especially for patients with bilateral carotid lesions. There have been some reports on risk factors for persistent hypotension after CAS[9,17,19,20]. Qureshi et Al.[20] mentioned that intraprocedural hypotension and history of myocardial infarction were both independent predictive factors of persistent hypotension.

In the present study, significant correlations were found between the occurrence of persistent hypotension and t factors such as distance from the carotid sinus to the lesion, plaque location and characteristics of the wall at the carotid bifurcation. Therefore, patients who have preoperative or intraoperative risk factors should be managed in an intensive care unit with monitoring of blood pressure and heart rate.

Conclusions

Although further investigation is required with respect to the long-term implication of blood pressure instability during or shortly after CAS, the risk factors described may be useful for predicting the occurrence of postprocedural hypotension including prolonged hypotension and for planning adequate postprocedural treatment. Prediction of prolonged postprocedural hypotension might be the most important method of preventing periprocedural ischemic complications of CAS.

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